§ 6. Polarization Measurement of High Power Millimeter Wave in LHD

Notake, T. (Nagoya Univ.), Idei, H. (Kyushu Univ.), Kubo, S., Shimozuma, T., Kobayashi, S., Mizuno, Y., Ito, S., Yoshimura, Y., Takita, Y., Ohkubo, K., Kasparek, W. (Stuttgart Univ.)

Electron cyclotron wave can heat plasma and drive toroidal current more locally than other heating methods. For local heating and current drive, the optimization of polarization is important. There exists cutoff of wave propagation in usual ECH/ECCD for high density. Using Electron Bernstein Wave (EBW), heating and current drive of the high density plasma becomes possible. For this purpose, an oblique injection to the magnetic field line is required as a result of a mode conversion process by O-X-B modes. In these experiments, to control the elliptical polarization is important.

The real-time monitor to measure the polarization of high power millimeter wave with 82.7GHz has been developed[1] and calibrated in the low power test stand which are composed of a Gaussian beam launcher, two synthesizers, a 3D-moving-stage, two harmonic-mixers, a multiplier, the vector network analyzer and so on[2]. The wire-grid polarizer was set up between the Gaussian beam launcher and the reflecting plate of the monitor system. The Gaussian beam of free space mode was injected directly to the reflecting plate through the wire-grid polarizer. The beam was injected with 45 degree tilt to x-axis of reflecting plate to achieve the high directivity. By adjusting the rotation angle of wire-grid polarizer, the incidence beam was linear polarized and the polarized plane was tilted to 45 degree to both x and y axes of reflecting plate, that is, the intensity of Ex and Ey is equal with the same phase. Here, x-axis is the same as the direction of the coupled electric field at the E-bend waveguide of reflecting plate as shown in Fig.1.

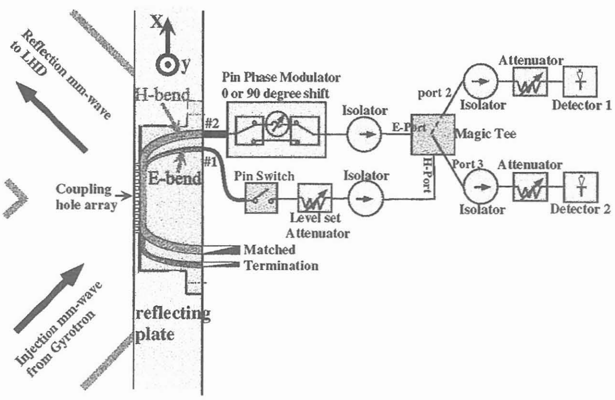

Figure1. Polarization monitor system

The insertion-loss difference between #1 and #2 circuits were calibrated by adjusting the level set attenuator in #1 circuit. On the other hand, the differences at the detector, the attenuator and the isolator connected with the magic-tee were calibrated using a Gunn-oscilator because detected power level became very low due to weak coupling at the holes. The phase difference resulted from different path length and phase errors of the phase modulator and the magic-tee, were measured directly using the vector network analyzer for each phase modulator states. Also, the phase difference can be deduced by measurements of interference signal intensity from both #1 and #2 circuits and noninterference signal from #2 circuit only. When the millimeter wave input from the #1 circuit is switched off by the pin switch, the signal power detected at the detector1 is expressed as A. The interference signal detected at the detector1 when the millimeter waves are input from the both #1 and #2 circuits are written as B. In this case, the phase differences between each path, which are included the phase errors by phase modulator and magic-tee, δ is obtained as $\cos\delta = (B/2A)$ -1 for each states. The comparison of measured phase differences between intensity measurement and directly phase measurement by vector network analyzer are given in Table 1. All the error ranges came from the uncertainty of the detected signals because detected signal level was very low as mentioned above. These results show that the calibration was done well.

State	From Intensity measurement	Direct phase measurement
P_0	$86\pm10°$	$89\pm5°$
P_{90}	$169\pm10°$	$177\pm5°$
P_{180}	$263\pm10°$	$260\pm5°$
P_{270}	$345\pm10°$	$353\pm5°$

Table 1. The comparison of measured phase difference

The polarization monitor system was installed in the transmission line of LHD, and the high power test was carried out with 82.7GHz gyrotron. A high power millimeter wave of about 250kW power was linear polarized and injected to the reflecting plate with changing α from -90 to +90 degrees for LHD toroidal direction by adjusting two polarizers based on the numerical calculation. Next, the azimuthal angle was fixed with zero, β was scanned. At the same time, sampling wave was detected by polarization monitor system. Here, α is the azimuthal angle and β is the ellipticity of the polarization.

The estimation results of polarization states using measured signals are shown in Figure2. The estimation values agree well with the setting values resulted from the numerical calculation for alpha and beta scanning.

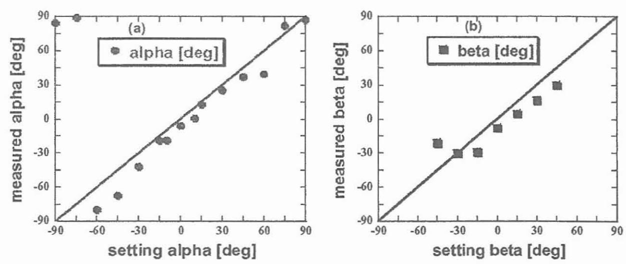

Figure2. The measured results for (a) alpha and (b) beta values.

References

[1] T.Notake, *et al.,* NIFS Annual Report, April2001-March2002

[2] H.Idei, *et al.*, in Proc.of the 26th IRMMW Conference. (2001)